AIR FORCE

QUALIFICATION TRAINING PACKAGE (AFQTP)

for

HVAC/REFRIGERATION

(3E1X1)

MODULE 19

BURNERS

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BURNERS

Career Field Education and Training Plan (CFETP) references from 1 Apr 97 version.

OPR: HQ AFCESA/CEOT
(SMSgt Michael R. Shakal)

Certified by: HQ AFCESA/CEO
(Colonel Lance C. Brendel)

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INTRODUCTION

Before starting this AFQTP, refer to and read the "Trainee/Trainer Guide" located on the AFCESA Web site **http://www.afcesa.af.mil/**

AFQTPs are mandatory and must be completed to fulfill task knowledge requirements on core and diamond tasks for upgrade training. ***It is important for the trainer and trainee to understand*** that an AFQTP ***does not*** replace hands-on training, nor will completion of an AFQTP meet the requirement for core task certification. AFQTPs will be used in conjunction with applicable technical references and hands-on training.

AFQTPs and Certification and Testing (CerTest) must be used as minimum upgrade requirements for Diamond tasks.

MANDATORY minimum upgrade requirements:

Core task:
AFQTP completion
Hands-on certification

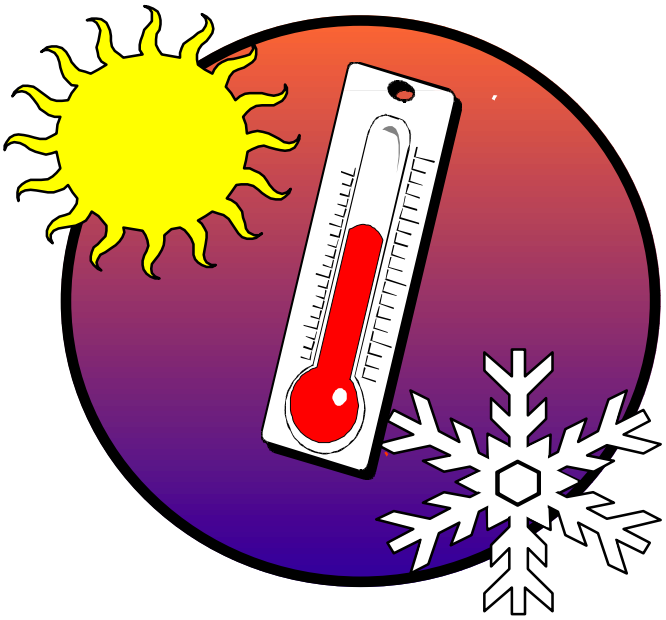
Diamond task:
AFQTP completion
CerTest completion (80% minimum to pass)

Note: *Trainees will receive hands-on certification training for Diamond Tasks when equipment becomes available either at home station or at a TDY location.*

Put this package to use. Subject matter experts, under the direction and guidance of HQ AFCESA/CEOT, revised this AFQTP. If you have any recommendations for improving this document, please contact the HVAC/R Career Field Manager at the address below.

HQ AFCESA/CEOT
139 Barnes Dr. Suite 1
Tyndall AFB, FL 32403-5319
DSN: 523-6421, Comm: (850) 283-6421
Fax: DSN 523-6488
E-mail: ceott.helpdesk@tyndall.af.mil

Notice. This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.



BURNERS

MODULE 19 **AFQTP UNIT 8**

ADJUST FUEL/AIR RATIO FOR PROPER COMBUSTION EFFICIENCY (19.8.)

ADJUST FUEL/AIR RATIO FOR PROPER COMBUSTION EFFICIENCY

Task Training Guide

STS Reference Number/Title:	19.8. Adjust Fuel/Air Ratio for Proper Combustion Efficiency
Training References:	• TR: ASHRAE Handbook, 1988 Equipment • William's Learning Network interactive CD-ROM: Combustion, Water, and Steam
Prerequisites:	• Possess as a minimum a 3E131 AFSC.
Equipment/Tools Required:	• Personnel Protective Equipment • Standard HVAC/R Tool Bag
Learning Objective:	• Trainee will know the steps to safely Adjust Fuel or Air Ratio for Proper Combustion Efficiency
Samples of Behavior:	• Trainee will be able to Adjust Fuel or Air Ratio for Proper Combustion Efficiency
Notes:	
• Any safety violation is an automatic failure.	

ADJUST FUEL/AIR RATIO FOR PROPER COMBUSTION EFFICIENCY

Background: Depending on the system you are operating, you could use any of the following methods. If you have an unchangeable fuel supply, then only adjust the amount of air the burner receives. With a constant air supply, you can only adjust the amount of fuel supply to the burner. With many others systems, both the air and fuel supplies can be adjusted to create complete combustion.

OIL BURNERS:

Pressure Adjustment. All pressure adjustments of a fuel pump should be made with the use of gauges. Do not adjust the pressure by guesswork or by merely observing the flame. Attach the pressure gauge at the port provided or wherever the manufacturer recommends.

Set the burner in operation and adjust the pressure. Normally set it at 100 psig or at the pressure setting specified by the manufacturer. You will find that a little time spent in proper pressure adjustments can result in oil savings to the Air Force. One thing should be remembered before you raise or lower the oil pressure: Whenever you change the oil pressure you change the firing rate (gallons-per-hour burned) of the burner.

While adjusting the pressure, start and stop the burner several times and watch the dial on the pressure gauge to see how quickly the pressure builds up. The pump should be at its operating pressure before the motor is up to speed.

To perform the task, follow these steps:

Step 1: Turn thermostat up all the way so burner will run long enough to complete this test.

Step 2: Locate the pressure regulating screw.

Step 3: Remove the nut covering the regulating screw.

Step 4: Place a screwdriver into the pressure regulating screw.

Step 5: Turn the screw counter-clockwise (the pressure should start decreasing). Turn the pressure down to 90 psi.

Step 6: Turn adjustment up to 110 psi.

Step 7: Now adjust pressure to maintain 100 psi

NOTE:
Whenever fuel pressure is changed, an air adjustment would normally be made. This will be accomplished in another objective**.**

To adjust the oil burner, follow these steps:

Step 1: Adjust electrodes.

NOTE:
Before adjusting the electrodes the nozzle must be installed in the fuel tube first. Make sure you snug it down because you will not be able to tighten it once the electrodes are set.

Step 1a: Place one electrode in the electrode-supporting clamp.

Step 1b: Adjust the electrode so that it is 1/2” above the center of the nozzle.

Step 1c: Now, adjust the electrode so that it is also 1/8” –1/4” ahead of the nozzle.

Step 1d: Next, slide the other electrode into place so that the two are even with each other, with a gap of 5/32" to 3/16" apart.

Step 1e: Tighten them down.

NOTE:
Insure the electrode sleeve is around the electrode in such a way that when the support clamp screws are tightened they come in contact with the sleeve and not the porcelain portion of the electrode. Do not over tighten, as this will crack the porcelain.

Step 2: Adjust the nozzle.

Step 2a: Slide the electrode assembly into the blast tube.

Step 2b: Align the fuel tube inlet in place.

Step 2c: Now slide the electrode assembly forward or back until there is a distance of 5/8” from the end of the nozzle to the end of the blast tube.

Step 2d: Tighten down the electrode assembly.

GAS BURNERS: An atmospheric gas burner is designed to operate with a specific gas supply pressure and a specific amount of primary air. The gas pressure and primary air adjustments must be checked periodically during a schedule recommended by the manufacturer or whenever the burner had undergone repair.

Gas Pressure Adjustment. The gas pressure is adjusted at the burner's gas pressure regulator. An instrument called a "manometer" is used to measure gas pressure at the burner manifold. The simplest form of manometer is the U-tube manometer.

It is composed of a "U" shaped glass or plastic tube attached to a scale marked metal or plastic frame. The tube will either contain colored water, oil, or mercury and can be used to measure either pressure or vacuum. One end of the tube will be vented to the atmosphere while the other end will be connected to a pressure tapping or vacuum test port. The force of the pressure or vacuum will displace the liquid and cause it to move. The amount of vacuum or pressure can be determined by first reading the scale at the liquid level on each side of the tube. Be sure to take the scale reading at the bottom of the "meniscus." The word meniscus is a laboratory term used to describe the inverted swell at the top of the liquid, as some of the liquid tends to cling to the internal surface of the tube.

After the scale readings have been taken, the actual pressure or vacuum can be calculated by adding the two scale readings. Pressure will be indicated as inches of water column (in. WC) when water or oil is used as the measuring liquid, or as inches of mercury, when mercury is used as the measuring liquid. Vacuum will be indicated as inches of water column or inches of mercury; however, a minus (-) sign must precede the vacuum measurement to indicate negative pressure.

First you must remove your jewelry. Then perform a pre-operational inspection. Next, set up the manometer that is attached to the furnace.

Hook up the gas line from the outlet side of the automatic gas valve by removing the allen screw and then putting in the brass adapter. Next, hook up the hose to the plastic adapter. Turn the two valves on the manometer a full turn from close to open then back up the hose to the reservoir connection. Then zero the meter. Start up gas burner and measure the gas pressure. It should be 3.5 inches of water column. Adjustments for the pressure regulator are clockwise, which causes an increase in pressure, counterclockwise causes a decrease in pressure. Let your trainer check your work, then shut down your unit and disconnect the manometer and install pressure tapping.

The manometer must be connected when the power and gas supply are turned off. After it is connected, the burner can then be operated in order to measure gas pressure. If the measured pressure is too high or too low, in reference to the manufacturer's specifications, then the tension on the pressure regulator spring needs to be adjusted. To increase gas pressure, turn the spring adjuster clockwise; to decrease gas pressure, turn the spring adjuster counterclockwise. Be sure to shut off the power and gas supply before removing the manometer from the pressure tapping on the regulator.

A slow burning yellow flame indicates insufficient primary airflow. A rapid burning and noisy flame that lifts off the burner ports indicate excessive primary airflow. In some burners, a slight amount of yellow tipping at the top of the flame is permissible. Orange streaks in the burner are caused by burning dust particles that have been drawn into the burner head and usually do not hinder the operation of the burner.

Pilot Burner Adjustment: The pilot flame should be adjusted to sufficiently contact the thermocouple, thermopile, or flame rod. It should also be large enough to provide immediate and positive ignition of the main burner. It can be adjusted in a similar manner as the main burner. Some pilots may have their own pressure adjustment screw. Aerated pilots will also have their own primary air shutters.

To properly adjust gas burner pressure, follow these steps:

Step 1: Remove jewelry.

Step 2: Pre-operational inspection of gas burner.

Step 2a: Electrical wiring and components.

Step 2b: Natural gas line and fittings.

Step 3: Set up manometer.

Step 3a: Remove pressure-tapping plug from gas valve

Step 3b: Install manometer to pressure tapping

Step 3c: Zero manometer

Step 4: Fire off gas burner.

Step 4a: Turn on electrical power (plug in the furnace)

Step 4b: Open gas SHUT-OFF valve

Step 4c: Check for gas leaks (soap solution)

Step 4d: Light pilot (standing pilots only)

Step 4e: Turn thermostat all the way up

Step 5: Adjusting gas burner pressure.

Step 5a: Remove cap from pressure adjustment on the combination gas valve.

Step 5b: Use a screwdriver to adjust gas pressure to 3.5 inches W.C.

i. Turn adjustment screw in for more pressure. (Clockwise)

ii. Turn adjustment screw out for less pressure. (Counterclockwise)

Step 6: Adjust air shutter.

Step 6a: Adjust air shutter for a blue flame with yellow tips

i. Open air shutter, more air

ii. Close air shutter, less air

Step 7: Shut down.

Step7a: Turn off thermostat

Step 7b: Secure electrical power

Step 7c: Secure combination gas valve (standing pilots only)

Step 7d: Secure gas SHUT-OFF valve

Step 7e: Remove manometer

Step 7f: Reinstall pressure-tapping plug

Combustion Analyzers. Since it is humanly impossible for you to actually see the gases of combustion in a boiler, you cannot know the actual combustion efficiency. You cannot feel exhaust gases and ascertain their degree of heat; you cannot perceive the amount of steam being produced. Therefore, it might be well for you to look to instrumentation as an extension of your own senses. Actually, your senses are the windows through which you can see and control what is taking place in your boiler plants. You should never depend on guesswork; and, in most instances, your guesses would be entirely wrong, or would come too late to be of any use.

Thermal Conductivity Analyzer. The thermal-conductivity analyzer operates on the principle that every gas has a somewhat different rate of heat transfer. Thermal conductivity is a property of all matter, including gases and vapors, where heat is transferred from a position of high temperature to a position of lower temperature by direct transfer from molecule to molecule. We refer to this as the second law of thermodynamics.

For analysis, the sample must be a mixture of the flue gas and a background gas. The amount of heat transfer changes as the amount of the measured gas increases or decreases. The thermal conductivity of the flue gases is compared to that of a standard reference gas. This is known as comparison analysis.

Specific-Gravity Analyzer. There are two hollow cylindrical chambers and each chamber contains a motor-driven impeller and a thrust wheel. The impeller on the bottom pulls in a continuous gas sample to be tested, and at the same time spins it at a high speed against the vanes of the top thrust wheel, creating a torque proportional to the sample gas density. At the same time, the top impeller pulls in a continuous sample of the surrounding air and spins it in the opposite direction of the sample gas but at the same speed. This action creates on its companion thrust wheel a torque proportional to the air density.

The difference between the two opposing torque’s is a measure of the specific gravity, and is transmitted through thrust-wheel pivot shafts and a sensitive linkage and lever arrangement to the pointer. This action moves the pointer over the indicating scale, and the pen over the clock-driven recording chart.

Portable Flue Gas Analyzer. The absorption type analyzer is a typical example of the simple portable chemical absorption analyzer. It is often referred to as the Fyrite analyzer. It consists of a container that holds a column of liquid that combines with the CO2 Gas. The top of the column has a plunger valve at the point where the CO2 enters. Along the side of the column is a scale that is calibrated from 0 to 20 percent for measuring the quantity of CO2. A tube and hand bulb transfers CO2 from the boiler or furnace stack to the indicator unit, where it mixes with the liquid and raises the level of the column to read the percentage of CO2 on the scale. The indicator is purged by depressing the plunger valve and setting the 0 mark on the percent scale even with the top of the column. Before you operate any CO2 indicating unit for the first time, carefully read the operational instructions from the manufacturer.

Digital Analyzer. The digital analyzer is a microprocessor based combustion analyzer. It will provide almost instantaneous information on all of the important factors in combustion testing such as percent oxygen, percent carbon dioxide (computed); net stack temperature (switchable between C and F); percent excess air, carbon monoxide concentration, smoke spot testing and percent combustion efficiency. *Before operating this analyzer read manufacturer's instructions very carefully.*

Combustion Control. Combustion control is the production of the required heat units by regulating the heating equipment fuel and air input to maintain constant steam pressure, water or air temperature, irrespective of load, and the proper relation of air to fuel supply for maximum combustion.

Combustion control not only has a very important economic influence because of fuel saving, but it also has significant effect on smoke abatement, since it promotes complete and efficient combustion. Operators should study until they completely understand the equipment combustion and safety control arrangements. This effort will substantially enhance normal operations, prolong the life of the equipment, and contribute to intelligent and safe emergency procedures.

Combustion Analysis. An efficient fire is fairly clear, not dark and smoky. The flame is long, billowing, and lazy, and is normally obtained by using a low furnace draft, but it is not long enough to enter the flue. The ideal fire does not cause carbon in the furnace, soot on the heating surfaces, or smoke from the chimney. An operator knows the appearance of an efficient oil or gas fire.

Oil Fire. An efficient oil fire has a clear, yellowish flame. The fact that the flame does not contain much smoke indicates the proper fuel-air ratio. A red flame with smoky tips indicates too little air. A short, white flame indicates too much air. A trace of smoke can be detected immediately after the oil has been ignited, but it soon disappears if the burner is correctly set.

Unburned particles of fuel, called sparklers, at the edge of the flame indicate poor air distribution and improper condition. The shape of the flame is controlled by dampers or fan speed. To ensure compliance with operating instructions, you should make an analysis of the flue gas after you have observed the condition of the flame.

Gas Fire. A gas flame is blue with yellow tips. With too little air, the flame is long, straggly, and yellow. With too much air, the flame is short, noisy, and tends to pull away from the burner. The flame should be stable and should not strike the burner tiles, walls, or boiler tubes. The shape of gas flame, like the shape of the oil flame is controlled by the burner air registers. The flow of air to the flame is controlled by dampers or fan speed. After you have observed the condition of the adjusted flame, you make an analysis of the flue gas to ensure efficient operation and compliance with operating instructions.

Smoke. As we said earlier, smoke is a good indication of combustion efficiency. Black smoke indicates that there is not enough air. White smoke indicates that there is too much air. A light-brown, hazy smoke indicates that the air-fuel ratio is about right for oil burners. When you are burning natural gas, there is no haze if you are getting proper combustion.

Combustion Efficiency. Combustion efficiency is the ratio of the useful heat delivered by the burning fuel to the supply of fuel. The most efficient combustion is that which releases the greatest amount of "useable" heat from fuel. Useable heat is that heat that is available for heating the boiler or furnace.

Computing Combustion Efficiency. The Combustion Efficiency Graphs may be used to determine the combustion efficiency when burning more common fuels. When you are using these graphs, it is necessary to know: first, the percentage of the CO2 in the flue gas; second, the temperature of the flue gas; third, the room temperature; and fourth, the type of fuel being used. With this information, you determine the combustion efficiency in the following manner:

Combustion Efficiency Graph. ***To properly read these graphs, follow these steps:***

Step1: Find the difference between the flue-gas temperature and room temperature. This is the net stack temperature.

Step 2: Locate, on the bottom of the scale, the point that represents the net stack temperature on the proper graph.

Step 3: Find the diagonal line that represents the amount of carbon dioxide in the flue gas.

Step 4: Find the point of intersection for the two lines.

Step 5: Draw a horizontal line to the left-hand scale from where the two lines intersect. The point at which the horizontal line crosses the left-hand scale represents the percentage of combustion efficiency.

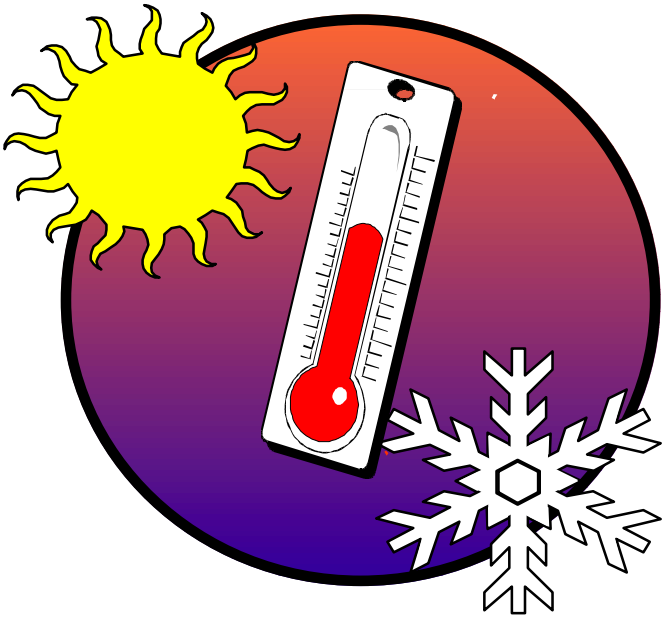
Review Questions
for
Adjust Fuel/Air Ratio for Proper Combustion Efficiency

Question	Answer
1. What type of flame should have a clear yellowish color?	a. Oil Fire b. Gas Fire c. Water Fire d. Wood Fire
2. The most efficient combustion is that which releases the greatest amount of useable heat from the fuel.	a. True b. False
3. What are the four factors used to compute combustion efficiency?	a. The percentage of the CO2 in a flue gas. b. Temperature c. The room temperature d. The type of fuel being used e. All the above
4. When you are burning natural gas, there is no haze if you are getting proper combustion.	a. True b. False

ADJUST FUEL/AIR RATIO FOR PROPER COMBUSTION EFFICIENCY

Performance Checklist		
Step	**Yes**	**No**
Operational Test		
1. Adjusting Gas Burner Pressure		
a. Remove Jewelry		
b. Pre-operational Inspection of Gas Burner		
c. Set up Manometer		
d. Fire off Gas Burner		
e. Adjusting Gas Burner Pressure		
f. Adjust Air Shutter		
g. Shut Down		
2. Pressure Adjustment of a Oil Pump		
a. Turn Thermostat up all the way		
b. Locate the pressure regulating screw		
c. Remove the nut covering the regulating screw		
d. Place a screwdriver into the pressure regulating screw		
e. Now adjust oil pressure to maintain 100 psig		

FEEDBACK: Trainer should provide both positive and/or negative feedback to the trainee immediately after the task is performed. This will ensure the issue is still fresh in the mind of both the trainee and trainer.



REPAIR COMPONENTS

MODULE 19 **AFQTP UNIT 10**

TROUBLESHOOT (19.10.1.)

CORRECT MALFUNCTIONS (19.10.2.)

TROUBLESHOOT

CORRECT MALFUNCTIONS

Task Training Guide

STS Reference Number/Title:	19.10.1. Troubleshoot 19.10.2. Correct Malfunctions
Training References:	• TR: ASHRAE Handbook, 1988 Equipment
Prerequisites:	• Possess as a minimum a 3E131 AFSC
Equipment/Tools Required:	• Personnel Protective Equipment • Standard HVAC/R Tool Bag
Learning Objective:	• Trainee will know the steps to safely Troubleshoot Components and Correct Malfunctions in Burners
Samples of Behavior:	• Trainee will be able to Troubleshoot Components and Correct Malfunctions in Burners
Notes:	
• Any safety violation is an automatic failure.	

TROUBLESHOOT

CORRECT MALFUNCTIONS

Background: Depending on the system you are operating, you could use any of the following methods. If you have an unchangeable fuel supply, then only adjust the amount of air the burner receives. With a constant air supply, you can only adjust the amount of fuel supply to the burner. With many others systems both the air and fuel supplies can be adjusted to create complete combustion.

Troubleshooting Oil Burners. Troubleshooting is a systematic process in which malfunctions in a mechanical system can be quickly and accurately identified and then corrected or repaired. By no means can this study guide provide you with all the information necessary for you to be an "ace" troubleshooter. Troubleshooting is a skill that can only be learned with actual hands on experience. Perhaps the most important thing to remember when you are troubleshooting an oil burner is to remain calm and be patient. Mechanics that become easily frustrated tend to fall into the trap of being "parts changers" instead of "problem solvers." Parts' changers will replace components on assumption and guesswork. This is an ineffective and expensive method of troubleshooting an oil burner.

Remember, troubleshooting is a systematic process. You must first ask yourself the obvious questions. Is the fuel tank empty? Are the oil supply valves open? Is there power to the burner? Are the burner controls such as the thermostat, aqua stat, or pressure control adjusted to operate the burner? You may think that this is an oversimplification of the troubleshooting process, but it is not.

All experienced troubleshooters begin at the source of electrical power and fuel supply when troubleshooting an oil burner. Only after those conditions have been proven do they proceed to troubleshoot the burner and its components.

Burner Short Cycles. The symptom might be that the burner starts and fires but short cycles. If this occurs, check the following sources for proper operation:

> **NOTE:**
> Follow manufacturers procedures to check correct operation of the limit control

1. Thermostat
    a. Correct heat anticipator setting
    b. No vibrations at thermostat
    c. No loose connections
2. Limit control
    a. Check filters
    b. Clean blower wheel

c. Proper limit setting

3. Power

a. Correct voltage

b. No loose connections

Burner Runs Continuously. The symptom might be too much heat, if so then check the following sources for proper operation. The problem could be coming from the thermostat or primary control. To isolate the problem disconnect thermostat wires at primary control. If burner shuts off, the problem is in the thermostat circuit. If it does not shut off, the problem is in the primary control.

1. Thermostat

a. No shorted or welded contacts

b. Thermostat level

c. Thermostat out of calibration

d. Shorted thermostat wires

Burner Fails to Start. The symptom might be no heat, if so, the problem could be coming from various sources. The best thing to do is to follow the manufacturer's recommendation to isolate the problem.

No Flame Established. The symptom might be burner motor comes on but no ignition, if so, the problem could be coming from various sources. The best thing to do is to follow the manufacturer's recommendation to isolate the problem.

Locks Out on Safety. The symptom might be burner starts and fires but trips out on safety. If this occurs the problem could be coming from various sources. The best thing to do is to follow the manufacturer's recommendation to isolate the problem.

It would not be practical to describe every specific troubleshooting procedure for an oil burner in this QTP. Many manufacturers may supply an easy reference, troubleshooting chart in their maintenance manual. These charts can aid the apprentice troubleshooter in solving oil burner problems by offering systematic step-by-step procedures.

Troubleshooting Gas Burners. The process of troubleshooting a gas burner is very simple. Before assuming that the components of the burner are malfunctioning, you must always make sure that electrical power and fuel is being supplied to the gas burner. Once you have established this, you can then systematically troubleshoot the burner components. Many burner troubles are caused by neglect. Burners that receive no periodic maintenance inspection, cleaning, or adjustment will have a relatively short service life and may eventually require costly repair. This QTP will address some of the more common troubles encountered with atmospheric gas burners.

Power. Before troubleshooting any component in the electrical circuits, check that the line voltage to the burner is correct.

Fuel. Insure that fuel is available to the burner by checking that gas valves are open.

Ignition Troubles. Directly or indirectly, the pilot light is usually responsible for most inoperative gas burners. Improper positioning of the thermocouple or thermopile on a standard pilot will prevent the pilot safety valve from opening. Improper positioning of the flame rod or spark igniter on an electronic spark ignition pilot system will cause similar problems. Another problem associated with the ignition system is an unstable pilot that can prevent positive contact with the thermocouple, thermopile or flame rod. This problem is normally caused by excessive air turbulence around the pilot burner and can be very difficult to identify. The source of the turbulence may not have anything to do with an improper burner adjustment. Air that surrounds a gas fired boiler or furnace can move in and out of the combustion chamber causing fluctuation of the pilot flame and perhaps even extinguish it. The same thing can occur from excessive updrafts and down drafts caused by improper chimney design or drastic weather changes. The only way to eliminate unwanted draft is to shield the combustion chamber with a specifically designed cover. In some cases, the stack or chimney may have to be reconstructed to prevent updrafts and down drafts.

If the presence of excessive draft problems are not evident and the pilot flame is still unstable, then the problem will most likely be either a dirty pilot orifice, low/high pilot gas pressure, or an improper primary air adjustment.

A couple of other pilot burner problems such as a bent or kinked pilot line and a rusty pilot orifice, should become evident to the experienced HVAC/R mechanic during a pre-operational inspection of the gas burner.

On a standard pilot ignition system, dirty or defective thermocouples, thermopiles, and flame rods can also cause their share of burner ignition problems.

Be sure that the thermocouple is in good condition. The pilot flame may be perfectly all right, but if the thermocouple lead is broken or kinked, it will short internally and will not be able to deliver current back to the electromagnet in the automatic gas valve.

The end of the thermocouple that screws into the electromagnet has a small insulator. If the nut has been tightened excessively, the insulator will collapse and short the thermocouple. If the nut has not been tightened enough, moisture may condense and cause corrosion. This will interfere with the current flow.

Since the current is in milli-volts, any dirt or oil on the thermocouple end (cold junction) may block current flow. Even the natural oil on your fingers may cause this.

A DC milli-volt meter can be used to determine if the thermocouple is defective. First, disconnect the thermocouple from the gas valve. Connect the meter lead from the negative terminal to the very end of the thermocouple lead. The positive terminal lead is clamped on the capillary. Now light the pilot. To do so, you will have to manually depress the reset knob on the gas valve to keep the pilot lit during the test. The meter needle should start to move. After the pilot has been lit for 5 minutes, a reading of 18 milli-volts or higher indicates a good thermocouple. When the meter needle has reached its maximum swing, release the knob on the valve and allow the pilot to go out. The meter needle should start dropping toward zero as the thermocouple cools off. If these readings are not obtained, the thermocouple is defective and must be replaced.

A milli-volt meter can also be used to test a thermopile however, the milli-volt readings will be higher. The minimum allowable voltage for a thermopile will be identified in the manufacturers' instructions.

To check an electronic spark ignition system, first shut off the gas supply to the burner and then remove the necessary access panel so that you can see the ignition electrode and pilot burner. Then, turn on the electrical power and adjust the operating control to turn on the burner. At this time, you should see a spark going from the electrode to the center portion of the pilot hood. Under normal operations, the spark must intersect the flow of gas as it leaves the pilot burner. If the spark travels to any other portion of the burner assembly, shut down the power to the gas burner and then adjust the position of the pilot burner or the electrode gap in accordance with the manufacturer's recommendations. Remember, the ignition electrode has a high voltage output of approximately 20,000 volts, so be extremely careful when you work with it.

If the spark ignition seems to be functioning properly, then the problem will most likely be with the pilot burner. Check to make sure that it is clean and properly adjusted.

If the spark ignition does not function at all, first check the input voltage to the electronic spark ignition system control with a voltmeter. If the minimum voltage is being supplied, then shut down the power to the burner and check the electrode and high-tension lead. If the ceramic insulation on the electrode is cracked, the spark may jump to the electrode bracket instead of the tip. If you can hear sparking, the spark igniter is good. The electrode is probably shorting to ground through the insulation. A worn, frayed or damaged high-tension lead can cause similar problems.

If the electrode gap and positioning are correct and everything else checks out, but there is still no spark at the electrode, the problem is in the solid-state circuitry of the ignition system. The only thing you can do at this point is replace the electronic spark ignition control.

Gas Control Troubles. If the burners ignition system is not operating properly, then the trouble may be in the pilot-stat or gas valve. These valves should be checked for poor electrical connections as well as improper operation of the energizing electrical coils. In some cases, it is necessary to clean the valve seats, plungers, and plunger tubes in solenoid gas valves.

Since these valves are expensive, extreme care should be taken to avoid damage to the internal mechanism. Always consult the manufacturer's instructions for gas valve repair procedures. If the fuel supply is suspected, use a manometer to check the gas pressure and the pressure regulator.

It would not be practical to describe every specific troubleshooting procedure for gas or oil burners in this QTP. The following charts can aid the apprentice troubleshooter in solving oil burner problems by offering systematic step-by-step procedures. Figures 1 and 2 show typical troubleshooting flow charts for gas burners.

Typical Troubleshooting Guide for an Oil Fired Warm Air Furnace

Trouble	Source	Procedure	Causes	Correction
Burner Starts and Fires but Short Cycles	Thermostat	Check Thermostat	Heat anticipator set too low Vibration at thermostat Thermostat in warm air draft	Correct heat anticipator setting Correct source of vibration Shield thermostat
	Limit Control	Connect voltmeter between line voltage connections to primary control. If burner cycles due to power interruption, it's cycling off limit	Dirty furnace air filters Burner running too slow Blower motor seized or burned out Blower bearings seized Blower wheel dirty Blower wheel in backwards Wrong motor rotation Restrictions in return or supply air system Adjustable limit control set too low	Clean or replace filter Increase blower speed Replace motor Replace bearings Clean blower wheel Reverse blower wheel Replace with properly rotating motor Correct cause of restriction Reset limit to maximum stop setting
	Power	If voltage fluctuates, fault is in the power source. Recheck voltage at power source	Loose wiring connection Low or fluctuating line voltage	Locate and secure connection Call power company
Burner starts, fires but looses flame & locks out on safety	Poor Fire	If burner continues to run (does not lock out on safety). Fault may be poor fire.	Unbalanced fire Too much air-lean short fire Too little air-long dirty fire Excessive draft Too little draft or restriction	Replace nozzle Reduce combustion air-check combustion Increase combustion air-check combustion Adjust barometric damper for correct draft Correct draft or remove restriction
	Flame Detector	If fire is good fault is in the flame detector. Check detector circuit	Dirty cad cell face Faulty cad cell face Loose or defective cad cell wire	Clean cad cell face Replace cad cell Secure connections or replace cad cell

Typical Troubleshooting Guide for an Oil Fired Warm Air Furnace

	Oil Supply	If burner loses flame (does not lock out on safety). Fault is in fuel system	Pump loses prime-air slug pump loses prime-air leak in supply Water slug in line Partially plugged nozzle or nozzle strainer	Prime pump at bleed port Check supply line for loose connections Check oil tank for water Replace nozzle
		Listen for pump whine	Restriction in oil line	Clear restriction
			Plugged fuel pump strainer Cold oil	Clean strainer or replace pump Change to number 1 oil
Burner Runs Continuously (too much heat)	Thermostat	If burner turns off, fault is in the thermostat circuit	Shorted or welded thermostat contacts Stuck thermostat bimetal Thermostat not level Shorted thermostat wires Thermostat out of calibration Thermostat in cold draft or not properly located	Repair or replace thermostat Clear obstruction or replace thermostat Level thermostat Repair short or replace wires Replace thermostat Correct draft or relocate thermostat
	Primary Control	If burner does not turn off, fault is in the primary control	Defective primary control	Replace defective primary control

Typical Troubleshooting Guide for a Gun-Type Oil Burner Fuel System

Trouble	Source	Procedure	Causes	Correction
Burner Starts but no Flame is Established	Ignition Electrodes	Remove gun assembly and inspect electrodes and leads	Fouled or shorted electrodes Dirty electrodes and leads Eroded electrode tips Improper electrode gap spacing Improper position of electrode tips Bad buss bar connection Cracked or chipped insulators Cracked or burned lead insulators	Clean electrode leads Dress up electrode tips & reset gap to manufacturers specifications Retention and realign Replace electrode Replace electrode leads
	Ignition Transformer	Connect ignition leads to transformer. Start burner and observe spark. Check line voltage to transformer primary.	Low line voltage Burned out transformer windings No spark or weak spark	Check voltage at power source Correct cause of voltage drop or call power company Replace transformer Properly ground transformer case
	Burner Motor	Motor does not come up to speed and trips out on overload. Turn off power and rotate blower wheel by hand to check for binding or excessive drag.	Improper voltage Pump or blower overloading motor Faulty motor	Check voltage at power source Correct cause of voltage drop or call power company Correct cause of overloading Replace motor
Burner Runs Continuously	Combustion	Check burner combustion for CO_2, stack temperature & smoke Low CO_2 less than 10 %	Too much combustion air Air leaks into heat exchanger around inspection door Excessive draft Incorrect burner head adjustment	Reduce combustion air Correct cause of air leak Adjust barometric damper for correct draft Correct burner head setting
		High smoke reading more than a trace	Dirty or plugged heat exchanger Insufficient draft Incorrect burner head adjustment Too little combustion air	Clean heat exchanger Readjust burner Increase draft Correct burner setting Increase combustion air

Typical Troubleshooting Guide for a Gun-Type Oil Burner Fuel System

		High stack temperature more than 550 F net	Too little blower air Blower belt too loose	Increase blower speed to maintain
			Dirty or plugged heat exchanger Dirty blower wheel Dirty furnace filters Restricted or closed registers or dampers	Proper temp rise Tighten blower belt Clean heat exchanger Clean blower wheel Clean or replace filter Readjust registers or dampers
	Oil Pressure	Inspect fire and check oil pressure	Partially plugged or defective nozzle Oil pressure too low less than 100 psi	Replace nozzle Increase oil pressure to 100 psi
Burner Starts & Fires but Locks out on Safety	Poor Fire	If burner continues to run, fault may be due to poor fire. Inspect fire	Unbalanced fire Too much air- lean short fire Too little air- long dirty fire Excessive draft Too little draft or restriction	Replace nozzle Reduce combustion air Increase combustion air Adjust Barometric damper for correct draft Correct draft or remove restriction
	Flame Detector	If fire is good, fault is in the flame detector. Check detector circuit	Dirty cad cell face Faulty cad cell Loose or defective cad cell wires	Clean cad cell face Replace cad cell Secure connections or replace cad cell holder and wire leads
	Primary Control	If burner locks out on safety, fault is in the primary control	Primary control circuit defective	Replace primary control
Burner Fails to Start	Thermostat	Check thermostat settings	Thermostat in off or cool Thermostat set too low	Switch to Heat Turn thermostat to a higher temp.
	Safety over loads	Check burner motor, primary safety control, & auxiliary limit switch	Burner motor overload tripped Primary control tripped on safety Auxiliary limit switch tripped on safety	Push pump motor reset button Reset primary control Reset Auxiliary limit
	Power	Check furnace disconnect switch & main disconnect	Open switch Blown fuse or tripped circuit breaker	Close switch Replace fuse reset circuit breaker

Typical Troubleshooting Guide for a Gun-Type Oil Burner Fuel System Typical

	Thermostat	Touch jumper wire across thermostat terminals on primary control. If burner starts, then fault is in thermostat circuit.	Broken or loose thermostat wires Loose thermostat screw connection Dirty thermostat contacts Thermostat not level Faulty thermostat	Repair or replace wires Tighten connection Clean contacts Level thermostat Replace thermostat
	Cad Cell	Disconnect flame detector wires at primary control. If burner starts, fault is in detector circuit.	Flame detector leads shorted Flame detector exposed to light Short circuit in flame detector	Separate leads Seal off false source of light Replace detector
	Primary Control	Place trouble light between the black and white leads. No light indicates no power to control.	Primary or auxiliary control switch open Open circuit between disconnect switch and limit control Low line voltage or power failure	Check adjustment Jumper terminals Trace wiring and repair or replace Call power company
		Place trouble light between the orange and white leads. No light indicates faulty control.	Defective internal control circuit	Replace control
	Burner	Place trouble light between the black & white leads to burner motor. No light indicates no power to the motor	Blown Fuse	Replace fuse
		Place trouble light between the black & white leads to burner motor. Light indicates power to motor & burner fault.	Binding burner blower wheel Seized fuel pump Defective burner motor	Turn off power & rotate blower wheel by hand. If seized, free wheel or replace fuel pump. Replace Motor
Burner Starts but no Flame is Established	Oil Supply	Check tank gauge or use dip stick Coat dip stick with litmus paste & insert to bottom of tank Listen for pump whine	No oil in tank Excessive Water in oil tank Tank shut off valve closed	Fill tank If water depth exceeds 1," pump or drain out water Open Valve

Typical Troubleshooting Guide for a Gun-Type Oil Burner Fuel System Typical

	Oil Filter & Oil Line	Listen for pump whine Open bleed valve or gauge port. Start burner. No oil or milky oil indicates loss of prime.	Oil line filter plugged Kinks or restriction in l oil line Plugged fuel pump strainer Air leak in oil supply line	Replace filter cartridge Replace or repair oil line Clean strainer or replace pump Locate and correct leak Tighten all connections
	Oil Pump	Install pressure gauge on pump & read pressure. Should not be less than 100 psi.	Pump partially or completely frozen No pressure and motor locks out on overload Coupling disengaged or broken Fuel pressure too low	Replace pump Re-engage or replace coupling Adjust to 100 psi
	Nozzle	Disconnect ignition leads. Observe oil spray. Inspect nozzle for plugged orifice or carbons build up around orifice.	Nozzle orifice plugged Nozzle strainer plugged Poor or off center spray	Replace nozzle with the same size, spray angle and spray type.

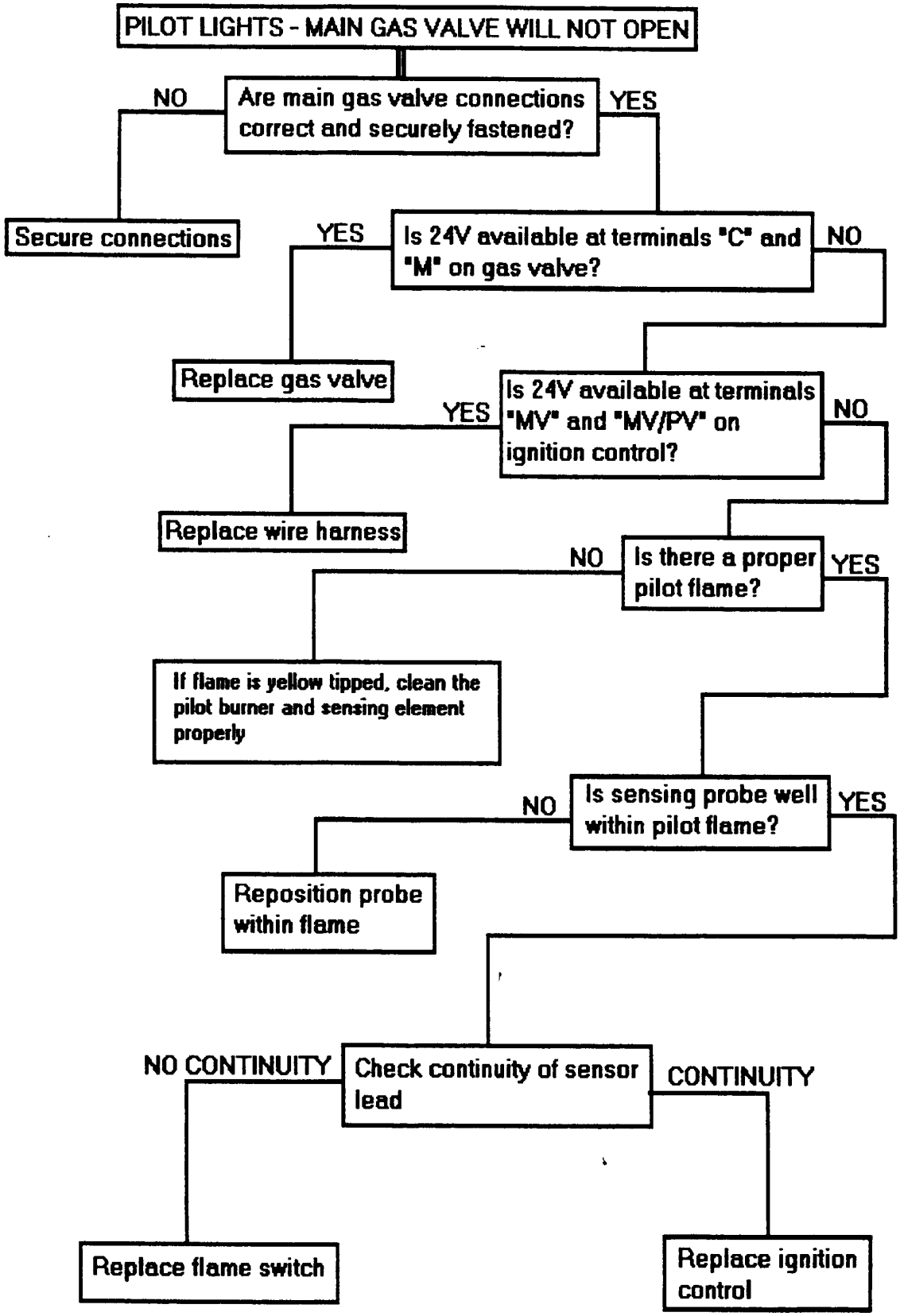


Figure 1, Troubleshooting Chart for Gas Burner

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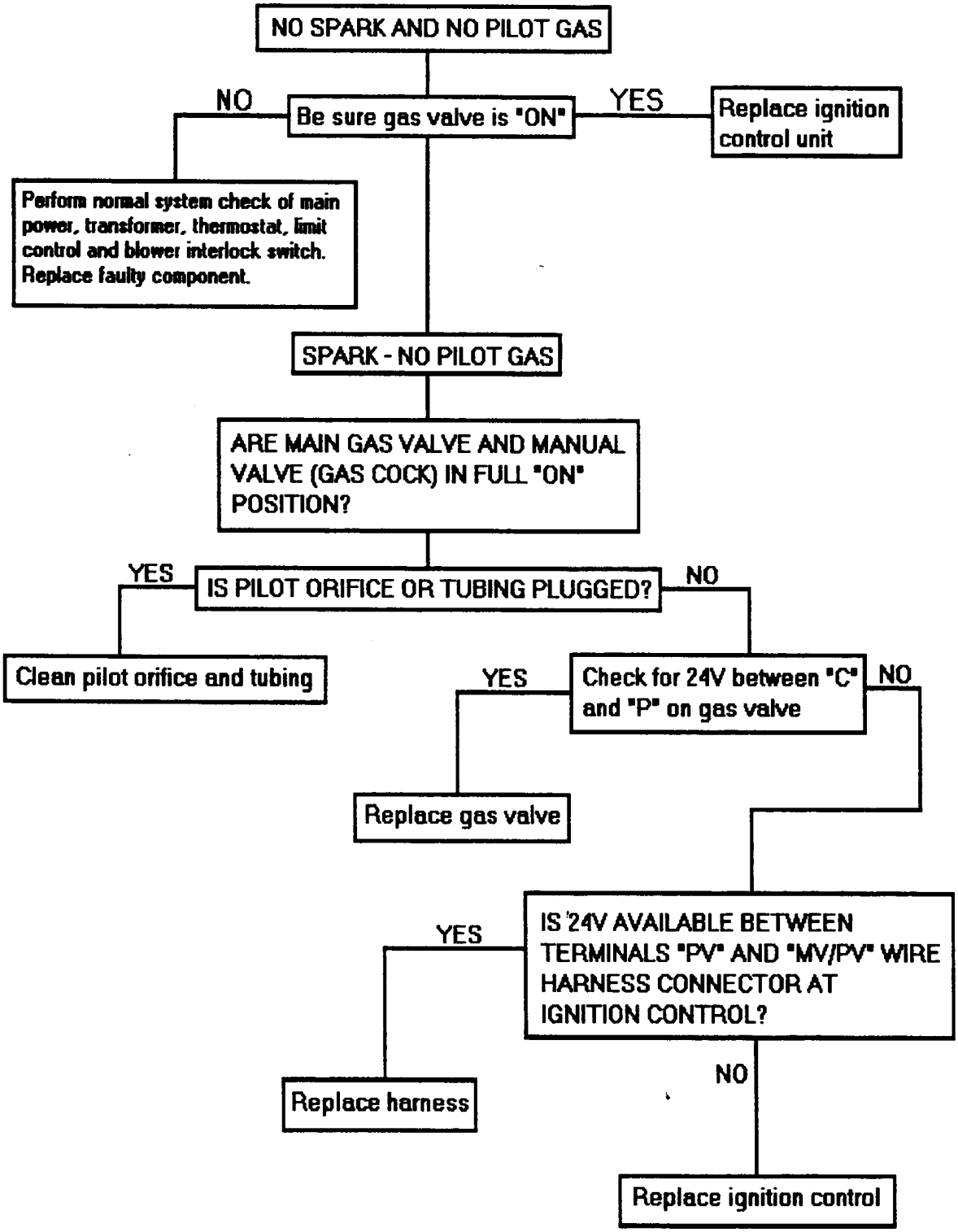


Figure 2, Troubleshooting Chart for Gas Burner

Review Questions
for
Troubleshoot

Correct Malfunctions

Question	Answer
1. Oil pressure in a gun type oil burner fuel system should be _____ psi.	a. 100 b. 105 c. 200 d. 300
2. All experienced troubleshooters begin at the source of electrical power and fuel supply when troubleshooting an oil burner.	a. True b. False
3. Directly or indirectly, the pilot light is usually responsible for most inoperative gas burners.	a. True b. False
4. Before troubleshooting any component in the electrical circuit, you should check the line voltage to the burner.	a. True b. False

TROUBLESHOOT

CORRECT MALFUNCTIONS

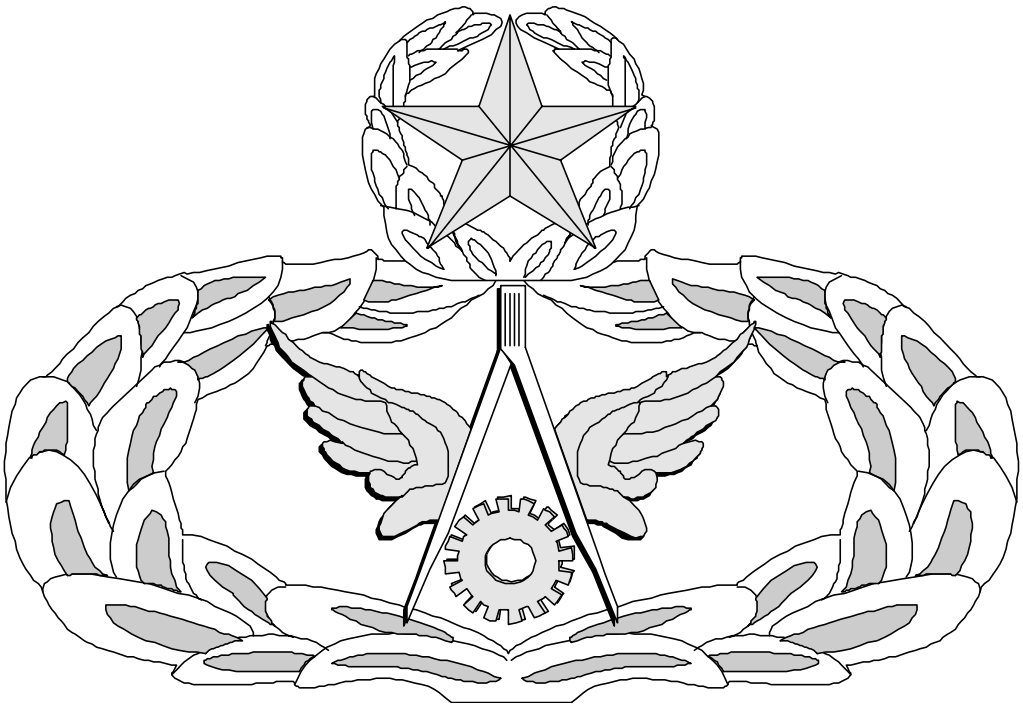
Performance Checklist		
Step	**Yes**	**No**
Operational Test		
1. Troubleshooting Oil Burner		
a. Check Burner Short Cycling		
b. Check Burner Runs Continuously		
c. Check Burner Fails to Start		
d. Check No Flame Established		
e. Check Locks on Safety		
2. Troubleshooting Gas Burner		
a. Check for Power		
b. Check for Fuel		
c. Check Ignition Troubles		
d. Check for Gas Control Troubles		

FEEDBACK: Trainer should provide both positive and/or negative feedback to the trainee immediately after the task is performed. This will ensure the issue is still fresh in the mind of both the trainee and trainer.

Air Force Civil Engineer

QUALIFICATION TRAINING PACKAGE (QTP)

REVIEW ANSWER KEY



For

HVAC/REFRIGERATION

(3E1X1)

MODULE 19

BURNERS

Notice. This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

ADJUST FUEL/AIR RATIO FOR PROPER COMBUSTION EFFICIENCY

(3E1X1-19.8.)

Question	Answer
1. What type of flame should have a clear yellowish color?	a. Oil Fire
2. The most efficient combustion is that which releases the greatest amount of useable heat from the fuel.	a. True
What are the four factors used to compute combustion efficiency?	e. All the above
3. When you are burning natural gas, there is no haze if you are getting proper combustion.	a. True

TROUBLESHOOT
(3E1X1-19.10.1.)

CORRECT MALFUNCTIONS
(3E1X1-19.10.2.)

Question	Answer
1. Oil pressure in a gun type oil burner fuel system should be _____ psi.	a. 100
2. All experienced troubleshooters begin at the source of electrical power and fuel supply when troubleshooting an oil burner.	a. True
3. Directly or indirectly the pilot light is usually responsible for most inoperative gas burners.	a. True
4. Before troubleshooting any component in the electrical circuit, you should check the line voltage to the burner.	a. True